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Technical Memorandum
Review of Final Responsiveness Summary for Aquifer Project Permit Application
Gunnison Copper Project

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Prepared for: Amerind Foundation
Dragoon, Arizona

Summary and Recommendations

The Arizona Department of Environmental Quality (ADEQ) responded to comments made by the public, including those made on behalf of the Amerind Formation, in a Final Responsiveness Summary, dated September 1, 2017, regarding the Gunnison In-situ Leach copper mine project aquifer protection permit (APP). Myers (2017) presented detailed comments on the APP and supporting documents, which ADEQ responded to in their summary.

ADEQ effectively accepted none of the comments made regarding the project, except to acknowledge the groundwater model would be updated periodically. The comments that would make a difference concerned point of compliance wells. They are too widely spaced to provide any confidence in them detecting a contaminant moving off of the site. ADEQ argues that wells closer to the well field will be more useful at detecting excursions. I believe the could be, but only by chance. They are not adequately space, either.

The groundwater model is not adequate to provide any confidence in the results. It implements hydrogeology only in a homogeneous/isotropic fashion while at the same time the fracture tests and pump tests show that both assumptions are far from accurate. There is little variability considered in the conductivity estimates. The model does not simulate the injection/collection wells, a failing which will limit the simulated pressure thereby not causing the particles as simulated to move from the well field as fast as they will with real operations.

The question is whether the APP should be appealed. I feel confidence we could show the fallacies of the modeling, but it would take a lot of work. The work would include some example modeling or the use of their model, if we could require them to turn it over. The

purpose would be to demonstrate the effects of some of the points raised below. These would include an analysis of improved POC spacing. It would probably be several weeks of work, even if we could get their model. I would want to update to include the injection/collection wells.

The larger question is this: what do we get from an appeal hearing? We are not going to show that the mine is a threat to Dragoon-area groundwater, simply because the flow gradients are to the east, not towards the community or its well. We do not have evidence to show their potentiometric surface maps (flow direction) are so wrong that the flow is actually toward Dragoon. That means I do not think we could get the project denied. The best we would get is a few more POC wells. I do not recommend an appeal because it is a huge effort for very little real potential gain.

Introduction

ADEQ responded to comments made by the public on the subject project APP in a Final Responsiveness Summary. This memorandum provides a reconnaissance level review of the Final Responsiveness Summary, which are responses that ADEQ made regarding the detailed comments provided regarding the proposed Excelsior In-Situ Leach copper mine. This memorandum assesses whether the APP should be appealed. In this memorandum, I discuss whether the ADEQ considered the comments. I divide the comments into two groups. The first deals with basic hydrogeology issues. The second deals with details of the groundwater model.

Hydrogeology Comments

At several points in the responsiveness summary, ADEQ refers to the long travel times for contaminants leaving the site, presumably if they bypass the hydraulic controls. For example, ADEQ refers to "greater than 23 years" from the "mine blocks to the POC wells" (ADEQ, p 11). These time estimates refer to estimates based on the groundwater model, which did not include either preferential flow zones or the pressure caused by the injection wells which, if not adequately countered by collection wells, could increase the speed the contaminants travel leaving the project.

ADEQ claims that the design and modeling accounts for horizontal anisotropy (Comment 6.2) and provides a series of figures to show the zone of influence from the pump test. These maps show that some faults may limit the extent the influence expanded in certain directions. However, they do not account for the fact that the response on one direction, within blocks created by the faults, could differ from the response in a different direction. Not only faults create horizontal anisotropy. The response also ignores the comments about how pressure in confined aquifers propagate in all directions and may not resemble the horizontal preferences.

Comment 6.3 expressed a need for a longer-term pump test to adequately test interactions with the underlying sulfide zone. ADEQ responded by referring to short-term tests in the sulfide showing it has a low conductivity. The short-term tests could have missed a connection. A well-monitored long-term test would show break-through from the underlying aquifer, if it occurs, at locations not limited to the points in which there is a monitoring well.

Comment 6.4 requested that Excelsior present the gamma tests in a way that would show the vertical distribution of fractures along the well bores as a way of discussing the variability in storativity/porosity, and the response is that "there is no evidence that the vertical flow is greater than horizontal flow or that the hydraulic barrier ... would not be effective". ADEQ was not responsive to the comment, although ADEQ had also combined three paragraphs that had variable issues into one comment, suggesting a lack of understanding of the comment.

ADEQ ignored the importance of a potential hydrocarbon leak, whether from the Johnson Camp Mine or the Thing gas station. Responses 6.5, 6.6 and 6.7 imply the project will merely remove any hydrocarbons. They ignore the potential for there being hydrocarbons in fracture zones that will not be affected by the project or that the hydrocarbons could affect the processing.

Response 6.8 essentially acknowledges the project description is very misleading. Excelsior calls it a five-spot pattern, which means there are four collection wells surrounding every injection well. That implies a 4:1 ratio of collection to injection wells. However, each collection well is part of the collection well set for more than one injection well, so the ratio is much less than 4:1.

ADEQ response to comment 6.9 stating the "overall injection rate is determined by the processing facilities capacities, not by injection pressure" is wrong. The rate may be limited by the need to limit the injection pressure to 0.75 psi/ft, but the pressure is a function of the injection rate, or vice versa. It is a simple matter of well hydraulics.

The ADEQ response to Comment 6.10 claims the geochemical model accounted for the estimated secondary porosity of 3% for the downgradient limestone. That is likely not correct, because they used a standard mixing model, not one that accounts for flow paths. Acid, with metals, escaping into the limestone would pass through fractures and the acid would contact only the wall of the fractures. The entire mass of limestone would not be available for neutralizing the acid.

ADEQ disagrees that additional point-of-compliance (POC) wells are needed because they argue the monitoring in the intermediate monitoring wells and observation wells are "more expedient" (Response to comment 6.13). These wells are near the hydraulic control wells and

will sample the groundwater as drawn into those wells. Only POC wells would detect contaminants actually leaving the well field. ADEQ does not respond to the part of the comment arguing the wells would be screened over too much of the aquifer and the samples would be highly diluted. They also suggest POC wells near lined impounds "would only be installed if there was an impoundment failure" (Id.), but they fail to disclose how they would know there is a failure without a monitoring well. Also, the ADEQ response to Comment 6.15 states the POCs related to the impoundments are conceptual.

ADEQ claims that "vertical profiling of groundwater at the POC well locations is not warranted or required due to the interconnectivity of the bedrock" (ADEQ response to comment 6.14). There is no evidence that ADEQ or Excelsior has considered that interconnectivity. Well screens that span more than one significant fracture zone allow water to mix so that contaminants in just one zone would be diluted by cleaner water from the other zones.

ADEQ rejects the concept that there should be POC wells along the north and south boundaries to "assure that contaminants do not flow in unpredicted directions" (Responsiveness Summary, p 32). ADEQ responds (to Comment 6.16) that more POC wells would be required if an evaluation of groundwater monitoring data shows they are necessary. Without any monitoring, ADEQ does not explain how monitoring would reveal that more POC wells are necessary.

ADEQ claims that the "groundwater monitoring and sampling methodology listed in Section 2.5.3 of the APP takes into account" concerns about the monitoring sampling being diluted (ADEQ response to comment 6.19). There is no discussion in that section, or anywhere else, regarding the fact that large screen lengths lead to diluted samples. A high concentration over a single layer intersecting the screen with others that are clean could dilute the sample.

POC sampling should consider some contaminants on a detect basis. If constituents that are not part of the natural background are even detected at the POC wells, it is evidence of an excursion from the well field and its hydraulic control.

ADEQ relies on long estimated travel times for solutions to reach the POC wells, over 23 years, to reject the arguments for an increased frequency of groundwater sampling (ADEQ response to Comment 6.22). The travel time estimates are for a modeled particle flowing through homogeneous model cells, not contaminants that have been injected at pressure possibly into the fracture zone through which they could flow to and past the POC wells.

Groundwater Model

I included many comments regarding the groundwater model used to simulate groundwater flow through the site and regional area. ADEQ responded to these comments only if I

presented them as a numbered comment. They did not consider the many comments about the model included in the introductory text. For example, from pages 44 to 49, I raised many issues about recharge distribution and its effect on conductivity (K) values, but ADEQ did not respond. From page 49 to 51, I discussed calibration in detail, but ADEQ did not respond. ADEQ failed to respond to many issues raised regarding the model.

ADEQ agrees that the groundwater model report did not include a water balance, but insists "the calibration analysis conducted by Excelsior demonstrates that the model is calibrated" (Comment 6.1). The problem is that it is not possible to evaluate a calibration without knowing the water balance. A first step in considering the reasonableness of a model is whether the flows are accurate. Without knowing the flow that discharges through the two gaps on the east side of the model domain, it is simply not possible to ascertain whether the numerical model adequately implements the conceptual flow model (CFM).

The table in the groundwater model report that shows K values showed that the model used the same K value in all three directions. In fractures especially, this is not correct. K is maximum in a direction parallel to the fractures and minimum in a direction transverse to the fractures. ADEQ, in the response to Comment 6.26, suggests that these differences are accounted for "by assigning hydraulic conductivity horizontally and vertically directly from the mine geologic model". The geologic model assigns K according to fracture density, which does not account for direction.

Different formations would fracture differently and it therefore follows the concomitant K value would also be different. But Excelsior set the K value for many different formations having the same fracture density. Comment 6.27 suggested there had not been enough done to establish different K for different formations. ADEQ response to comment 6.27 does not address why there are no differences among formations.

In comment 6.29, I incorrectly identified Table 11 as the source of K value – it should have been Table 9 that shows for fracture intensity 5, that the Naco, Escabrosa, Martin, Upper Abrigo, Middle Abrigo, Lower Abrigo, Bolsa Quartzite, and Precambrian rocks have Kx=Ky=Kz=65 ft/d. Application App I shows figures for the model that do not have K values greater than 10 ft/d.

ADEQ response to comment 6.32 states that ADEQ disagrees that simulating each injection and collection well is necessary – they do "not agree that discretizing he model to have individual cells for each well is required". I take this to mean they would have to create a model cell for each well, which means they would have to make the model cells smaller or situated differently than they are currently. The model currently has cells within the well field that are 75 feet square, and Excelsior describes the five-spot pattern as being "within a 100 foot square, with an injection well in the center and 4 recovery wells surrounding it on the corners of the square

(APP, Appendix I, p 25). I would model this with 50-foot square cells, with each well centered in the square. Clear Creek apparently did not plan in advance to simulate the well field, and a request at this time would require a lot of work.

ADEQ claims the "injection and recovery rates within the mine block are to be approximately equal so the water level is maintained" (ADEQ response to comment 6.32). they are correct the rates would be approximately equal, but the water level would be a series of mounds and drawdown cones around the injection and collection wells, respectively. The simulation would allow ADEQ to understand the variability within well field. They should require some glitches to be modeled. For example, a couple collection wells could be shut to see how long before contaminant excursions would occur.

The groundwater model was used in particle tracking mode to estimate to where and how fast a particle would travel away from the well field. In ADEQ response to comment 6.33, they do not agree, but it is difficult to ascertain what they do not agree with. The comment was that the particles would not be under pressure if the injection well, which would actually release the contaminants, were not simulated. They did not consider that particles under pressure would move much faster than if they are not under pressure.

Additionally, in ADEQ response to comment 6.34, ADEQ effectively repeats that it does not agree that simulating individual wells or "decreasing the grid size adds any predictive value". They state that "[w]ithin the 5-spots, injection and recovery is planning on being approximately equal" (Id.). Because each collector well would be part of up to four 5-spots, that would be very complicated and difficult to achieve on a consistent basis. One reason put forth by ADEQ is they do not have sufficiently detailed hydrogeologic information to justify such detailed discretization. If that is correct, it would seem they do not have sufficient hydrogeologic information to actually develop this mine.

ADEQ response to comment 6.37 essentially rejects the concept that modeling could lead to a better design of POC wells. The comment was that plume modeling should be used to estimate a proper spacing of POC wells. The wells should not be spaced wide than the plumes. It would also be useful to estimate the vertical dispersion so that proper screen intervals could be estimated.